International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 3, March 2017, pp. 193–200 Article ID: IJCIET_08_03_020
Available online at http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=3
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

EFFECT OF FLY ASH ON MECHANICAL PROPERTIES OF M30 AND M60 GRADE CONCRETE

A. Venkateswara Rao
Associate Professor, Department of Civil Engineering,
K.L University, Vijayawada - 522502, Andhra Pradesh, India

K. Srinivasa Rao
Professor, Department of Civil Engineering, College of Engineering,
Andhra University, Visakhapatnam - 530003, Andhra Pradesh, India

ABSTRACT

Concrete is one of the highest consumed primary construction material in the world with a vital role in the construction field. Production of one ton of cement produces nearly one ton of CO_2 causing environmental problems. So there is a need to reduce cement production and use some additives to make concrete sustainable. Due to growing environmental awareness, there is an increasing interest in the use of fly ash. It can be used either as an admixture or as partial replacement of cement or as partial replacement of fine aggregate and also as supplementary addition to achieve different properties of concrete. This paper presents the experimental investigations on the effect of fly ash content on compressive strength of M60 and M30 grades of concrete at an age of 7, 28, 56 and 91 days.

Key words: Concrete, Fly ash, Compressive strength, Cement.

Cite this Article: A. Venkateswara Rao and K. Srinivasa Rao, Effect of Fly Ash On Mechanical Properties of M30 and M60 Grade Concrete. *International Journal of Civil Engineering and Technology*, 8(3), 2017, pp. 193–200.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=3

1. INTRODUCTION

Concrete has been the leading, extensively used construction material as its ingredients are easily available, manufacturing cost of it is less and also durable over other construction material. Cement is one of the chief ingredients, also responsible for strength of concrete and globally the demand for cement is increasing year by year due to increase in utility of cement for the development of infrastructure and sustainability, Previous investigations reveals that concrete has been prepared by introducing some additives called as mineral admixtures, beside its basic ingredients to investigate their effect on strength, durability and other properties of concrete. Fly ash is one such material easily available as it (fly ash) is the waste product in

thermal plants. Past investigations [1, 2] have revealed that fly ash can be utilized as an important constituent of concrete. It can be used with partial replacement of cement, or replacement of fine aggregate. The present study involves in replacement of cement with different percentages of fly ash and its performance at different ages of concrete.

2. PREVIOUS STUDIES

Aman Jatale,et al. [3] have studied the effect on strength and mechanical properties of M15, M20 and M25 grades of concrete by replacing cement with 20, 40 and 60% of fly ash. Tests for compression are conducted on 150 mm cubes. It was concluded that with use of fly ash, workability improved, setting time increases, strength and modulus of elasticity decreases. The decrease in strength at early ages is more. Finally concluded that fly ashcan be gain fully used in making concrete strong, durable, Eco-friendly and economical.

Dragas, J., et al.[4] reviewed the research on properties of concrete replacing cement by 30-70% of fly ash and the mechanisms are discussed and concluded that with addition of fly ash water demand for given workability decreased, strength and modulus of elasticity decreased and with w/c ratio below 0.4 and addition of fly ash more than cement replaced gives more strength compared to the results of conventional concrete without fly ash.

Nath, P. and Sarker, P. [5] investigated the durability properties of high strength concrete replacing cement with 30 and 40% of class F fly ash sourced from Western Australia. The 28 day compressive strength, drying shrinkage sorptivity and rapid chloride permeability were determined. It was concluded that the 28 day compressive strength varied from 65 to 85 MPa and the fly ash samples showed less drying shrinkage over control concrete specimens without fly ash, inclusion of fly ash reduced sorptivity and chloride ion permeation significantly.

3. EXPERIMENTAL PROGRAM

3.1. Mix Proportions

The present experimental investigation on concrete consists of replacing cement with varying fly ash content of 30, 40 and 50% by weight of cement besides one mix without fly ash, total four mixes are selected. The mix proportion of the present study is 1: 1.39: 3.43 and 1 : 1.8 : 3.14 (cement: fly ash: fine aggregate: coarse aggregate) and water content of 0.32 and 0.48 for M60 and M30 grades of concrete respectively obtained from guide lines of IS: 10262-2009 [6] and IS: 456-2000 [7] and the proportions are finalized after testing several trial mixes. The Ordinary Portland cement of 53 grade [8], fine aggregates conforming to zone-II, coarse aggregate as per IS:383 [9] code provisions, class F fly ash [10] collected from N.T.P.C, Visakhapatnam are used for present study. No admixture is used for M30 grade concrete and SP 430 DIS [10, 11] is used as admixture for M60 grade concrete.

3.2. Method of testing

The cubes of 100 mm and cylinders of 150 mm diameter and 300 mm height are prepared for studying the response of different concrete mixes at elevated temperatures. The specimens are demoulded after 24 h from the time of casting and placed in potable water for curing. After specified period (7, 28, 56 and 91 days) of curing the specimens are removed from water and allowed to dry in air Three specimen cubes of 100 mm size are tested in 3000 kN compression testing machine as per IS 516 [12] at ages of 7, 28, 56 and 91 for each percentage, age and the average value of compressive strength is considered. Three specimen cylinders are tested in 3000 kN compression testing machine as per IS 5816 [13] at ages of 7, 28, 56 and 91 for each percentage, age and the average value of compressive strength is considered Cubes during casting and cube specimen under compression test are shown in Fig.1 and Fig.2 respectively.

Figure 1 Cubes during casting

Figure 2 Cube under compression test

4. RESULTS AND DISCUSSIONS

4.1. Compressive strength

Percentage compressive strength is the ratio of compressive strength of any percentage of fly ash or age to that of 28 day strength of controlled concrete (reference concrete) at room temperature multiplied by 100. Behaviour of fly ash on compressive strength of M60 and M30 grades of concrete are shown graphically in Fig.3 and Fig.4 respectively.

From Fig.3, the values of percentage compressive strength of M60 grade concrete (HSC) for 0, 30, 40 and 50% fly ash at room temperature at an age of 7 days are 95.5, 94.1, 92.8 and 87.4. At the same time, the values at an age of 28 days are 100.00, 101.5, 99.8 and 97.9, While, the values at an age of 56 days are 103.3, 104.7, 102.3 and 99.5, whereas the values at an age of 91 days are 105.3, 108.6, 105.6 and 101.5 respectively.

From Fig.4, the values of percentage compressive strength of standard concrete for 0, 30, 40 and 50% fly ash at room temperature, at an age of 7 days are 90.2, 88.6, 87.9 and 77.2. At the same time, the values at an age of 28 days are 100, 102.2, 89.6 and 79.3. At the same time the values at an age of 56 days are 103.3, 104.6, 100.6 and 97.2, whereas the values at an age of 91 days are 105.2, 107, 103.9 and 99.6 respectively.

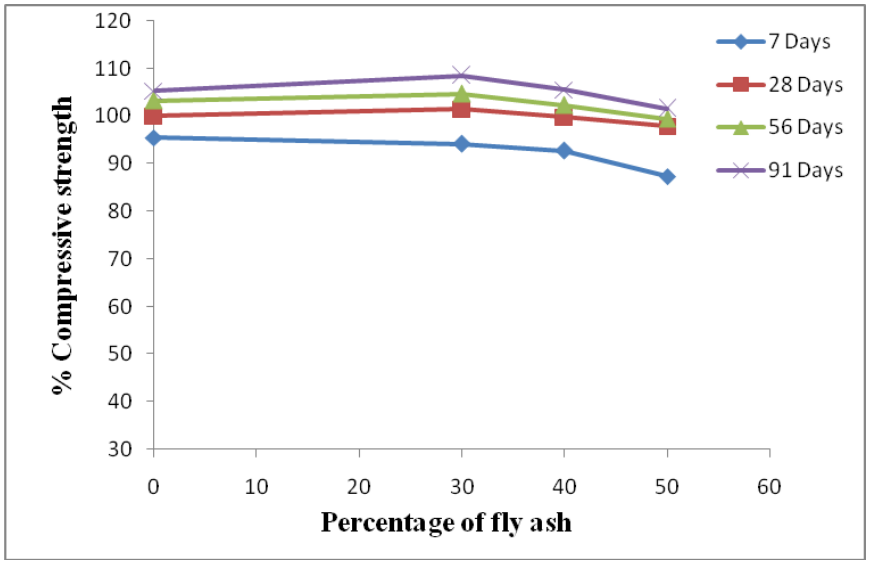

Figure 3 Variation of percentage compressive strength with percentage of fly ash for M60 grade concrete at room temperature

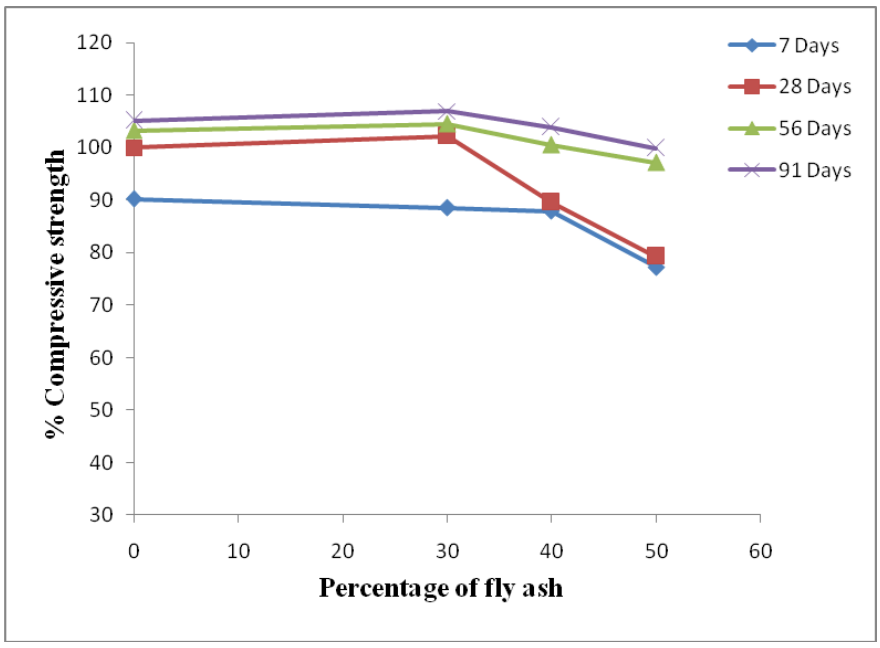

Figure 4 Variation of percentage compressive strength with percentage of fly ash for M30 grade concrete at room temperature

4.2. Split tensile strength

Percentage split tensile strength is the ratio of split tensile strength of any percentage of fly ash or age to that of 28 day strength of controlled concrete (reference concrete) at room temperature multiplied by 100. Behaviour of fly ash on split tensile strength of M60 (HSC) and M30 (SC) grades of concrete are shown graphically in Fig.5 and Fig.6 respectively.

From Fig.5, the values of percentage split tensile strength of HSC for 0, 30, 40 and 50% fly ash at room temperature at an age of 7 days are 88.2, 86.6, 84.7 and 68.5. At the same time, the values at an age of 28 days are 100.0, 101, 97.7 and 92.3, While, the values at an age of 56 days are 101.0, 102.3, 101.9, 98.3, whereas the values at an age of 91 days are 104.8, 106.6, 102.9 and 100.0 respectively.

From Fig.6, the values of percentage split tensile strength of SC for 0, 30, 40 and 50% fly ash at room temperature at an age of 7 days are 88.7, 87.7, 84.0 and 77.2. At the same time, the values at an age of 28 days are 100, 102.4, 96.5, 85.9, While, the values at an age of 56 days are 102, 103, 100.3 and 92.3, whereas the values at an age of 91 days are 106.8, 108.6, 104.7 and 101.89 respectively.

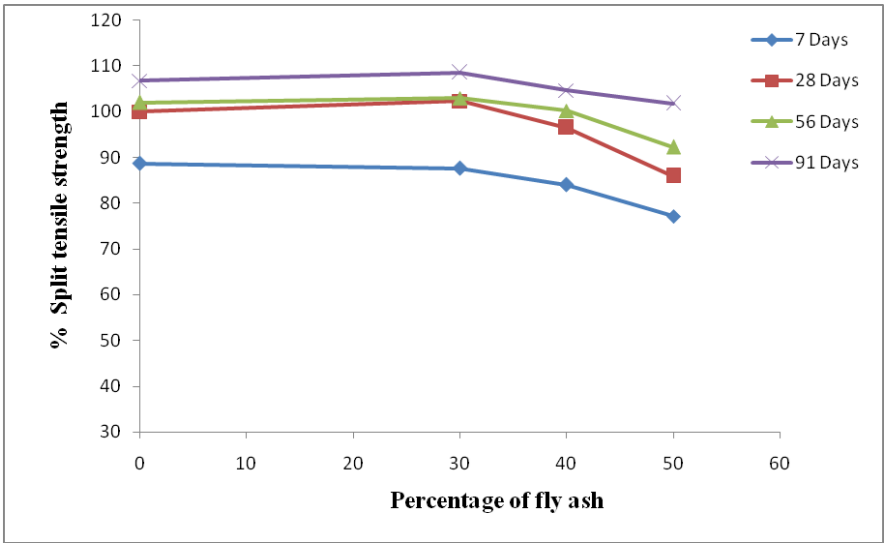

Figure 5 Variation of percentage residual split tensile strength with percentage of fly ash for M60 grade concrete at (27°C) room temperature

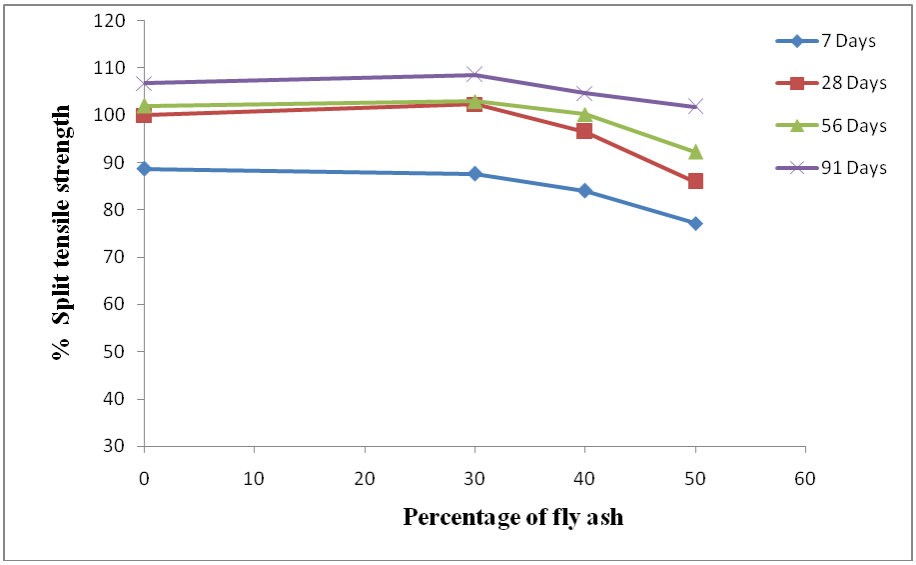

Figure 6 Variation of percentage residual split tensile strength with percentage of fly ash for M30 grade concrete at (27°C) room temperature

4.3. Stress-Strain behaviour

The Stress-Strain behaviour of high strength concrete (M60) and standard concrete (M30) with various replacements of cement with 0, 30, 40 and 50% of fly ash is shown in Fig.7 and Fig.8 respectively. The experimental results revealed that the replacing cement between 30% to 50% with fly ash ductility and stiffness was decreased for M60 grade concrete and for M30 grade concrete, the replacing cement between 30% to 50% with fly ash ductility and stiffness was decreased.

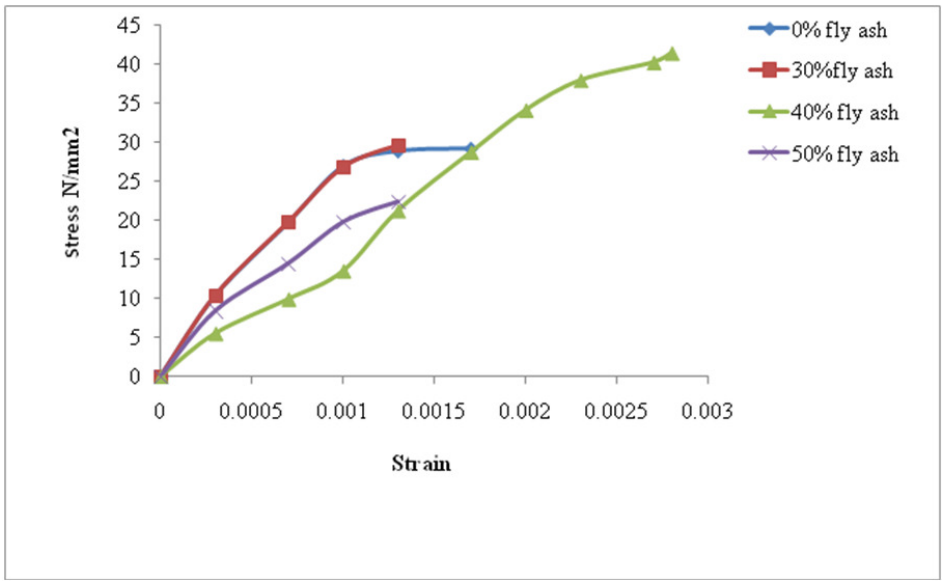

Figure 7 Variation of Stress-Strain at room temperature for M60 grade concrete

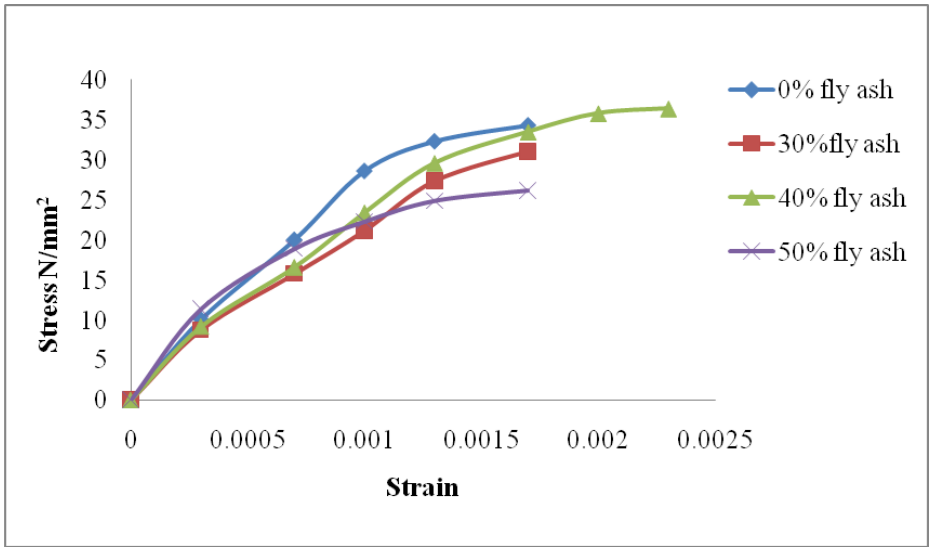

Figure 8 Variation of Stress-Strain at room temperature for M30 grade concrete

CONCLUSIONS

1. Compressive strength of M60 grade concrete increases for 30% ly ash concrete compared to controled concrete without fly ash at all ages of 28, 56 and 91 days.
2. Compressive strength of M30 grade concrete increases for 30% ly ash concrete compared to controled concrete without fly ash at all ages of 28, 56 and 91 days.
3. At an age of 7 days the compressive strength of M60 grade concrete decreases for 30, 40 and 50% fly ash concrete compared to controled concrete without fly ash.
4. Compressive strength of M30 grade concrete decreases for 30, 40 and 50% fly ash concrete compared to controled concrete without fly ash at an age of 7 days.
5. Compressive strength of M30 and M60 grades of concrete decreases for 40 and 50% fly ash concrete compared to controled concrete without fly ash and concrete with 30% fly ash at all ages of 28, 56 and 91 days.
6. Percentage of residual split tensile strength of M60 grade concrete increases for 30% ly ash concrete compared to controled concrete without fly ash at all ages of 28, 56 and 91 days.

7. Split tensile strength of M30 grade concrete increases for 30% ly ash concrete compared to controled concrete without fly ash at all ages of 28, 56 and 91 days.
8. At an age of 7 days the split tensile strength of M60 grade concrete decreases for 30, 40 and 50% fly ash concrete compared to controled concrete without fly ash.
9. Split tensile strength of M30 grade concrete decreases for 30, 40 and 50% fly ash concrete compared to controled concrete without fly ash at an age of 7 days.
10. Split tensile strength of M30 and M60 grades of concrete decreases for 40 and 50% fly ash concrete compared to controled concrete without fly ash and concrete with 30% fly ash at all ages of 28, 56 and 91 days.
11. Concrete with high percentages of above 40% fly ash can be used in situations where strength is not important economy is required.
12. At early ages the compressive strength of fly ash concrete is less over conventional concrete without fly ash.
13. At early ages the split tensile strength of fly ash concrete is less over conventional concrete without fly ash.
14. Finally it is concluded that concrete replacing cement with 30% fly ash can be used in construction of structures.

REFERENCES

[1] Hand Book on High Volume Fly Ash Concrete Technology, 3 rd edition (2005).

[2] Malhotra, V.M.; Mehta, P.K.: High Performance High Volume Fly Ash Concrete. Supplement Cementer Materials for Sustainable Development. Inc., Ottawa, Canada (2005).

[3] Aman Jatale, Kartikey Tiwari, Sahil Khandelwal, "Effects on Compressive Strength When Cement Is Partially Replaced By Fly-Ash", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 5, Issue 4 (Jan. - Feb. 2013), PP 34-43.

[4] Dragas, J, Mrinkovic, S., Igrjatovic, Tovic, N., " Properties of High Volume Fly Ash Concrete And its Role in Sustainability Development" International Conference on Contemporary Achievements in Civil Engineering, 24-25 April 2014, Subotica, Serbia.

[5] Nath, P., and Sarker, P., "Effect of Fly Ash on the Durability Properties of High Strength Concrete" Science Direct, The Proceedings of the Twelfth East Asia- Pacific Conference on Structural Enginering and Construction, Vol.14, 2011, pp. 1149-1156.

[6] IS 10262-2009, “Recommend Guidelines for Concrete Mix Design”, Bureau of Indian Standards, New Delhi, India.

[7] IS 456-2000, "Indian Code of practice for Plain and Reinforced concrete for genaral building construction Bureau of Indian Standards, New Delhi, India.

[8] IS: 12269 Specifications for 53 grade Portland cement, Bureau of Indian Standards, New Delhi, India.

[9] IS 383-1970 specifications for Coarse and Fine Aggregates from natural sources for concrete, Bureau of Indian Standards, New Delhi, India.

[10] IS: 9103-1999, "Specifications for Admixtures for concrete", Bureau of Indian Standards, New Delhi, India.

[11] Manual on Complast SP 430-DIS from Foscroc Chemicals Ltd.

[12] IS 516-1959(Reaffirmed 1999) Indian Standard Methods 0f tests for strength of concrete, Bureau of Indian Standards, New Delhi. India.

[13] Ahmed Sahib Mahdi, Mohammad Sukri Mustapa, Mohd Amri lajis and Mohd warikh abd Rashid, Effect of Holding Time on Mechanical Properties of Recycling Aluminium Alloy Aa6061 through Ball Mill Process, International Journal of Mechanical Engineering and Technology, 6(9), 2015, pp. 133-142.

[14] S. Kiran Kumar and Dr. S. Siddiraju, Effect of Steel and Polypropylene Fiber on Mechanical Properties of Concrete. International Journal of Civil Engineering and Technology, 7(3), 2016, pp.342–346.

[15] Bibha Kumari and Vikas Srivastava, Effect of Waste Plastic and Fly Ash on Mechanical Properties of Rigid Pavement. International Journal of Civil Engineering and Technology, 7(5), 2016, pp.247–256.

[16] G. Vamsi Durga Mohan, K. S. Rao and P. Srinivasa Rao. Enhancement in Mechanical Properties of Vibratory Welded Joints: An Overview. International Journal of Mechanical Engineering and Technology, 8(2), 2017, pp. 50–55.

[17] IS 5816-1999, "Method of test for splitting tensile strength of concrete", Bureau of Indian Standards, New Delhi, India.

[18] Saha Arkan , et al., (2014), Strength Development Characteristics of High Strength Concrete Incorporating an Indian Fly ash", "International Journal of technology enhancements and emerging engineering research", vol.2, issue 6, (2014), pp. 101-107.